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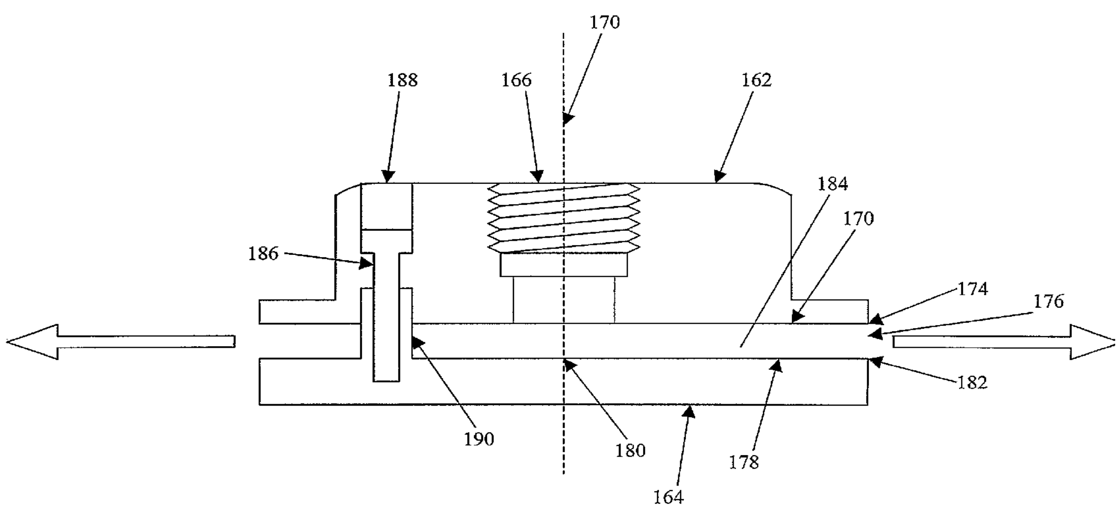
(54) Title: NOZZLE APPARATUS AND METHOD FOR ATOMIZING FLUIDS



(57) Abstract: An atomizing nozzle for a fire suppression system, having a nozzle body and a deflector body secured together. A flow passage defined between the deflector body and nozzle body extends radially outwardly from an inlet port to a circumferential outlet slot, the outlet slot being defined between the nozzle body and deflector body and extending at least partially around the. Vanes are disposed in the flow passage, and are arranged so as to impart to fluid flowing through said flow passage a tangential velocity component relative to the axis of the flow passage. The vanes may be arranged such that the tangential velocity component is sufficient to impart to gas in the area a rotational motion about the axis. The vanes may be removable, and may be retrofitted to existing nozzles. The nozzles also may be removable, and may be retrofitted to existing fire suppression systems.

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Nozzle Apparatus and Method For Atomizing Fluids

The application is being filed on 03 June 2005, as a PCT International Patent application, in the name of Kidde-Fenwal, Inc., a U.S. national corporation, applicant for the designation of all countries except the US, and Joseph A. Senecal, a U.S. citizen, applicant for the designation of the US only, and claims priority to U.S. Utility Application Serial No. 10/865,175, filed June 9, 2004.

Field of the Invention

This invention relates to an apparatus and method for atomizing fluids, such as fire suppressing fluids. The invention relates more particularly to an apparatus and a method for efficiently distributing an atomized fluid via a nozzle throughout a volume filled with air or other gas, in such a way as to impart a transverse velocity component as well as a radial component to the fluid.

Background of the Invention

There are a wide variety of fire suppression systems commercially available today. One form of fire suppression system is known as a fixed "clean agent" gaseous fire suppression system. Clean agent fire extinguishing systems extinguish fires by creating a fire extinguishing atmosphere consisting of agent vapor or gas mixed with the air within the protected space. Clean agent systems are used in buildings and other such structures to suppress fires without water, powder or foam so not as to destroy or damage an area of the structure and/or equipment contained therein. Clean agent fire suppressants leave no residue upon evaporation. One common form of clean agent is a chemical that is in liquefied form under normal storage conditions but which may be vaporized to form a gaseous mixture with air which does not support combustion and extinguishes fires. Such liquefied-gas suppressants exist in liquid form when confined in a closed container, but exist as a gas at ambient temperature and when not confined in a container.

Clean agent suppressants typically must either displace the oxygen and/or fuel near a fire, or mix with the air near the fire until a concentration is reached at which the fire is no longer supported. If the suppressant either does not reach a particular point or does not build up to sufficient levels at that point, flames at that location may persist. Thus, it is often desirable to disperse the suppressant thoroughly, rapidly, and evenly throughout the entire area that a given nozzle or system is meant to protect.

Conventionally, such suppressants are distributed in a radial motion only. That is, the suppressant is expelled from a nozzle or similar structure and

expands outward radially from that nozzle. In principle at least, this results in an expanding sphere of suppressant gas emanating from the nozzle.

However, this conventional arrangement is not entirely satisfactory.

For example, a radial distribution of suppressant may be susceptible to interference from objects in the protected area, such as production equipment, storage units, etc. Such objects may constitute obstacles to a radial flow of suppressant, interfering with thorough dispersion of the suppressant. For example, if a piece of equipment is disposed between a conventional radial nozzle and a flame, the radial path that the suppressant otherwise might follow to reach the fire may be blocked. In such instance, the suppressant may not reach and/or build up in the area of the fire as quickly as might be the case if the obstacle were not present. Similar effects may occur if the protected area is not uniform in shape.

Moreover, a conventional radial distribution typically takes the form of one or more discrete plumes of suppressant, extending outward from the nozzle. As a result, the spaces between plumes may have less suppressant than the areas of the plumes themselves. Thus, the initial distribution of suppressant may be less even than might be desired.

Conventionally, attempts to improve the distribution of suppressant have relied on increased suppressant pressure, increased suppressant volume, and/or an increased number of nozzles. However, this may result in the use of more suppressant, stronger distribution systems, and/or more nozzles than might otherwise be necessary for protected area of a given size.

Summary of the Invention

It is the purpose of the claimed invention to overcome these difficulties, thereby providing an improved apparatus and method for distributing a fluid, particularly a fire suppressant.

An exemplary embodiment of an atomizing nozzle in accordance with the principles of the present invention includes a nozzle body and a deflector body secured together in fixed relation. The nozzle body has an inlet port through the nozzle body that is adapted for connection with an outlet port, so that the nozzle may receive fluid therefrom.

The nozzle also has a flow passage defined between the deflector body and the nozzle body. The flow passage extends radially outwardly from the inlet port to a circumferential outlet slot, which is defined between the nozzle body and the deflector body and extends at least partially around the nozzle.

The flow passage defines an axis thereof.

The nozzle also includes vanes disposed in the flow passage. The vanes are arranged so as to impart a tangential velocity component relative to the axis to fluid flowing through the flow passage.

The vanes may be arranged such that the tangential velocity component is sufficient to impart to gas in the area a rotational motion about the axis.

The ratio of the magnitude of the tangential velocity component of the suppressant to the magnitude of the radial velocity component of the suppressant may be at least 1:10; that is, the tangential velocity component may be at least one tenth as large as the radial velocity component. Alternatively, the ratio may be at least 1:5. The ratio may be at least 1:3. The ratio may be at least 1:2.

The flow passage of the atomizing nozzle may extend 360° around the axis. Alternatively, the flow passage may extend less than 360° around the axis. In particular, the flow passage may extend 180° around the axis.

The vanes may be removable. The vanes may be formed as a single, integral unit.

An exemplary embodiment of a fire suppression system in accordance with the principles of the present invention includes a supply of a volatile liquefied-gas fire suppressant having a vapor pressure sufficient to form a gaseous mixture with air that does not support combustion, for extinguishing fires. The system also includes a pipe network connected to the supply, the pipe network including at least one outlet port.

At least one atomizing nozzle is in communication with the outlet port. The atomizing nozzle includes a nozzle body and a deflector body secured together in fixed relation, the nozzle body having an inlet port therethrough connected to the outlet port of the pipe network.

A flow passage is defined between the deflector body and the nozzle body, the flow passage extending radially outwardly from the inlet port to a circumferential outlet slot. The circumferential outlet slot is defined between the nozzle body and the deflector body and extends at least partially around the nozzle.

The flow passage defines an axis thereof.

Vanes are disposed in the flow passage, arranged so as to impart to the suppressant a tangential velocity component relative to the axis.

The vanes may be arranged such that the tangential velocity component is sufficient to impart to gas in the area a rotational motion about the axis.

The ratio of the tangential velocity component of the suppressant to the radial velocity component of the suppressant may be at least 1:10, that is, the

tangential velocity component may be at least one tenth as large as the radial velocity component.

The flow passage of the atomizing nozzle may extend 360° around the axis. Alternatively, the flow passage may extend less than 360° around the axis. In particular, the flow passage may extend 180° around the axis.

An exemplary embodiment of a kit for retrofitting an atomizing nozzle in accordance with the principles of the present invention is suited for a nozzle having a nozzle body and a deflector body secured together in fixed relation, with the nozzle body having an inlet port therethrough adapted for connection with an outlet port, so as to receive fluid therefrom. The nozzle also suitably has a flow passage defined between the deflector body and the nozzle body, the flow passage extending radially outwardly from the inlet port to a circumferential outlet slot, the circumferential outlet slot being defined between the nozzle body and the deflector body and extending at least partially around the nozzle, with the flow passage defining an axis thereof.

The kit includes vanes adapted to be disposed in the flow passage in an arrangement so as to impart a tangential velocity component relative to the axis to fluid flowing through the flow passage.

The vanes may be adapted to be arranged such that the tangential velocity component is sufficient to impart to gas in the area a rotational motion about the axis.

The vanes may be adapted to be arranged such that the ratio of the magnitude of the tangential velocity component of the suppressant to the magnitude of the radial velocity component of the suppressant is at least 1:10.

The vanes may be formed as a single, integral unit.

The kit may include instructions for retrofitting the nozzle.

An exemplary embodiment of a kit for retrofitting fire suppression system in accordance with the principles of the present invention is suited for a system having a supply of a volatile liquefied-gas fire suppressant with a vapor pressure sufficient to form a gaseous mixture with air that does not support combustion, for extinguishing fires. A pipe network suitably is connected to the supply, the pipe network having at least one outlet port.

The kit includes at least one atomizing nozzle. The nozzle includes a nozzle body and a deflector body secured together in fixed relation, the nozzle body having an inlet port therethrough adapted for connection with the outlet port, so as to receive fluid therefrom. The nozzle also includes a flow passage defined between the deflector body and the nozzle body, the flow passage extending radially outwardly from the inlet port to a circumferential outlet slot, the circumferential

outlet slot being defined between the nozzle body and the deflector body and extending at least partially around the nozzle. The flow passage defines an axis thereof.

The kit also includes vanes disposed in the flow passage, arranged so as to impart a tangential velocity component relative to the axis to fluid flowing through the flow passage.

The kit vanes may be arranged such that the tangential velocity component is sufficient to impart to gas in the area a rotational motion about the axis.

The vanes may be arranged such that the ratio of the magnitude of the tangential velocity component of the suppressant to the magnitude of the radial velocity component of the suppressant is at least 1:10.

The flow passage may extend 360° around the axis. Alternatively, the flow passage may extend less than 360° around the axis. In particular, the flow passage may extend 180° around the axis.

The kit may include instructions for retrofitting the system.

An exemplary method of suppressing a fire in accordance with the principles of the present invention includes communicating a volatile liquefied-gas fire suppressant to at least one nozzle, the nozzle defining an axis, atomizing the fire suppressant with the nozzle so as to vaporize the fire suppressant to a gaseous state, and imparting to the fire suppressant a tangential velocity component relative to the axis.

The tangential velocity component may be sufficient to impart to gas in the area a rotational motion about the axis.

The ratio of the magnitude of the tangential velocity component of the suppressant to the magnitude of the radial velocity component of the suppressant may be at least 1:10; that is, the tangential velocity component may be at least one tenth as large as the radial velocity component. Alternatively, the ratio may be at least 1:5. The ratio may be at least 1:3. The ratio may be at least 1:2.

The suppressant may exit the nozzle in an arc extending 360° around the axis. Alternatively, the suppressant may exit the nozzle in an arc less than 360° around the axis. In particular, the suppressant may exit the nozzle in an arc extending 180° around the axis.

The fire suppressant may be sprayed in a liquid state in a fan sufficiently thin such that the fire suppressant vaporizes without substantial liquid contact with the structure wherein the nozzle is disposed.

An exemplary method of suppressing a fire in an area in accordance with the principles of the present invention includes communicating a volatile

liquefied-gas fire suppressant to at least one nozzle, the nozzle defining an axis, atomizing the fire suppressant with the nozzle so as to vaporize the fire suppressant to a gaseous state, and imparting to gas in the area a rotational motion about the axis.

The fire suppressant may be sprayed in a liquid state in a fan sufficiently thin such that the fire suppressant vaporizes without substantial liquid contact with the structure wherein the nozzle is disposed.

An exemplary method of retrofitting an atomizing nozzle in accordance with the principles of the present invention is suited for a nozzle having a nozzle body and a deflector body secured together in fixed relation, with the nozzle body having an inlet port therethrough adapted for connection with an outlet port, so as to receive fluid therefrom. The nozzle also suitably has a flow passage defined between the deflector body and the nozzle body, the flow passage extending radially outwardly from the inlet port to a circumferential outlet slot, the circumferential outlet slot being defined between the nozzle body and the deflector body and extending at least partially around the nozzle, with the flow passage defining an axis thereof.

The method includes disposing vanes in the flow passage, the vanes being arranged so as to impart a tangential velocity component relative to the axis to fluid flowing through the flow passage.

The tangential velocity component may be sufficient to impart to gas in the area a rotational motion about the axis.

The ratio of the magnitude of the tangential velocity component of the suppressant to the magnitude of the radial velocity component of the suppressant may be at least 1:10.

An exemplary method for retrofitting a fire suppression system in accordance with the principles of the present invention is suited for a system having a supply of a volatile liquefied-gas fire suppressant with a vapor pressure sufficient to form a gaseous mixture with air that does not support combustion for extinguishing fires, and a pipe network connected to the supply, the pipe network including at least one outlet port.

The method includes connecting at least one atomizing nozzle to the outlet port. The nozzle includes a nozzle body and a deflector body secured together in fixed relation, the nozzle body having an inlet port therethrough adapted for connection with the outlet port, so as to receive fluid therefrom. The nozzle also includes a flow passage defined between the deflector body and the nozzle body, the flow passage extending radially outwardly from the inlet port to a circumferential outlet slot, the circumferential outlet slot being defined between the nozzle body and the deflector body and extending at least partially around the nozzle, the flow

passage defining an axis thereof. Vanes are disposed in the flow passage, the vanes being arranged so as to impart a tangential velocity component relative to the axis to fluid flowing through the flow passage.

The tangential velocity component may be sufficient to impart to gas in the area a rotational motion about the axis.

The ratio of the magnitude of the tangential velocity component of the suppressant to the magnitude of the radial velocity component of the suppressant may be at least 1:10.

Brief Description of the Drawings

Like reference numbers generally indicate corresponding elements in the figures.

Figure 1 is a partly schematic illustration showing an exemplary embodiment of a fire suppression system in accordance with the principles of the present invention.

Figure 2 shows the system of Figure 1 with the fire suppression system in an active fire suppression mode.

Figure 3 is an external top view showing an exemplary embodiment of a nozzle in accordance with the principles of the present invention.

Figure 4 shows a cross section of an exemplary embodiment of a 360° nozzle in accordance with the principles of the present invention, similar to that in Figure 3, taken along line A-A.

Figure 5 shows a cross-section of the nozzle in Figure 4, taken along line B-B.

Figure 6 shows a cross section of another exemplary embodiment of a 360° nozzle in accordance with the principles of the present invention.

Figure 7 shows a cross section of an exemplary embodiment of a 180° nozzle in accordance with the principles of the present invention.

Figure 8 shows a cross section of another exemplary embodiment of a 360° nozzle in accordance with the principles of the present invention, similar to that in Figure 3, taken along line A-A.

Detailed Description of the Preferred Embodiment

For purposes of illustration, an exemplary embodiment of a fire suppression system in accordance with the principles of the present invention is illustrated in Figure 1. Therein, a fixed clean agent fire suppression system **110** is shown, incorporating a plurality of atomizing nozzles **112** for an area **114** of a building **116** or other similar structure (e.g. a large vessel, etc.). For purposes of

orientation and reference, the building **116** includes a floor **118**, a ceiling **120**, and a plurality of walls **122** extending vertically between the floor and ceiling.

The system **110** generally includes a pipe network **124** of multiple interconnected pipes **125** for communicating volatile liquefied-gas fire suppressant toward the area **114**. The pipe network **124** may be an existing network previously used, for example as part of a Halon 1301 system, such that the disclosed fire suppression system is a retrofit system. Alternatively, the pipe network **124** may be a new set of plumbing for a newly installed system. In either event, the pipe network **124** generally has an input end **126** for receiving clean agent and a plurality of outlet ports **128** for discharging clean agent into the area **114**. In a typical system, the pipe network **124** generally extends throughout the ceiling **120** and/or the walls **122** of the building **116**. In either event, the outlet ports **128** are typically provided by vertically downward extending branch pipes **130**.

At the input end **126**, the pipe network is connected to a tank or cylinder **132** of liquefied-gas fire suppressant **134** through a valve **136**. The valve may be a two-way valve, or other suitable valve having open and closed states for selectively allowing or preventing flow. Depending on the particulars of a given embodiment, the valve **136** may be actuated by a user control **137** or an automatic control in response to a fire sensor, to allow the liquefied-gas fire suppressant **134** to flow through the pipe network **124**.

The gas fire suppressant **134** is stored in a liquefied state in the cylinder **132**. Typically, the liquefied-gas fire suppressant will be stored at a low pressure of between 0.4 psig and **100** psig at room temperature, 25 °C. In the exemplary embodiment described herein, the gas fire suppressant **134** comprises at least one of the following liquefied-gases: 1,1,1,2,3,3,3-heptafluoropropane (HFC-227ea), and 1,1,1,3,3,3-hexafluoropropane (HFC-236fa). The more commonly used HFC-227ea has a boiling point of about -16.4 °C (2.5 °F.) such that it normally assumes a gaseous state at room temperature, 25 °C. Although two suppressing agents are disclosed, other agents may be equally suitable. For example, it will be appreciated that the system is generally applicable to fire suppressants comprising at least one liquefied-gas selected from the following classes: hydrofluorocarbons, perfluorocarbons, and hydroclorofluorocarbons, chemical variations of these which may include other atoms within the molecular structure such as oxygen, or other suitable liquefied-gases that act as fire suppressants (including but not limited to certain forms of halogenated ketones, aldehydes, alcohols, ethers, and esters).

It is an aspect of the present invention that a piston flow system may be used to push the gas fire suppressant **134** through the pipe network **124**. In particular, a tank or cylinder **140** of a gas propellant **142** may be arranged in fluid

series with the clean agent cylinder **132**. The propellant **142** may be a non-condensable gas, such as nitrogen or argon, or a liquefied compressed gas, such as carbon dioxide, which has a much lower boiling point than the fire suppressant **134** such that it provides a large pressure and propelling force for pushing the fire suppressant **134** through the pipe network **124**. The gas propellant **142** is selected for fire safety and also to provide suitable propelling force by having a low boiling point. Suitable propellants for the system **110** include, but are not limited to, any of the following gases: carbon dioxide, nitrogen, and argon.

The compressed gas or liquefied compressed gas propellant **142** is stored separately from the liquefied fire suppressant **134**. A connecting hose **146** connects the vapor area or gas zones **148, 150** above the liquid in the cylinders **132, 140**. Preferably, mixing of the vapor area gas zones **148, 150** is prevented with an on/off propellant valve **159** between the cylinders **140, 132** separating the propellant and clean agent. The propellant valve **159** may be the outlet valve of the propellant cylinder **140**. In the alternative, some of the gas propellant **142** may also be allowed to enter the agent gas zone **148** in the clean agent cylinder **132** to maintain a high pressure load on the gas fire suppressant **134** in the compressed liquid state. A check valve **152** (which may also be a pressure relief valve) may also be arranged between the cylinders **132, 140**. The check valve **152** is used to allow propellant **142** to enter the clean agent cylinder **132** while in an open state while preventing reverse flow while in the closed state. The piston flow system is also arranged such that when the propellant valve **159** is open, only propellant in the gaseous state enters the clean agent cylinder **132**. By only allowing gaseous propellant **142** to enter the cylinder **132**, there is very little mixing or dissolving of propellant into the contained liquid of fire suppressant.

Upon the occurrence of a fire in the area **114**, the on/off propellant valve **159** and the on/off system valve **136** are opened by the manual control **137** or an automated control in response to a sensor. These two valves **136, 159** may be linked such that the opening of one causes the other to open as well. According to one implementation, the propellant valve **159** is actuated to an open position releasing high pressure propellant. The on/off system valve **136** is connected to pressure downstream of the propellant valve **159** and actuated by this pressure.

Once the valves **136, 159** are opened, the propellant **142** pushes the fire suppressant **134** in a liquid state out of the agent cylinder **132** through a siphon tube **154** that has a fluid inlet **156** proximate the bottom of the cylinder **132**. It will be appreciated to those skilled in the art that an alternative to the siphon tube **154** is to place the outlet port of the agent cylinder at or near the vertical bottom of the cylinder, again for the purposes of drawing the fire suppressant in liquid form. In

either event, the fire suppressant **134** is delivered and pushed out of the agent cylinder **132** in a compressed liquid state into the pipe network **124**. As the liquid volume in the agent cylinder **132** drops, more high pressure propellant **142** is drawn off of the liquid supply of the propellant cylinder **140** and enters the agent cylinder **132** in gaseous form through the check valve **152** and connecting hose **146**. The propellant **142** maintains pressure on the fire suppressant **134** to push it out through the siphon tube **154** in the compressed liquid state until the agent cylinder **132** is empty. The rate of transfer of the propellant to the agent container is limited by a selectively sized flow restriction **157** located at the inlet of the check valve **152**. The restriction **157** is selectively sized to provide a predetermined pressure to the clean agent and a predetermined flow rate of clean agent through the pipe network. The size of the restriction **157** is a variable that is selected and can be changed from system to system to meet the particular system requirements.

By preventing the propellant **142** from dissolving in the liquefied-gas fire suppressant **134**, the fire suppressant **134** advantageously maintains a one phase liquid state when being pushed through the pipe network **124**. The propellant **142** maintains a high enough pressure on the fire suppressant **134** to maintain the one phase liquid state despite a small pressure drop upon entering the pipe network **124**. Virtually no propellant **142** dissolves into the liquefied-gas fire suppressant **134** being delivered through the pipe network **124**. As such, vaporization of propellant **142** in the pipe network **124** is not a problem. This maintains a high mass flow rate of compressed liquefied-gas fire suppressant **134** through the pipe network because the volume of the pipe network **124** is occupied by a one phase high-density liquid instead of a two phase low-density liquid and gas combination.

While the disclosed embodiment achieves a high mass flow rate, there is no dissolved propellant in the liquefied-gas fire suppressant **134** to break the discharged fire suppressant **134** into small droplets for more rapid vaporization. The disclosed embodiment resolves this issue through another aspect of the invention, namely, a plurality of atomizing nozzles **112** mounted to the outlet ports **128** of the pipe network **124**.

However, it is emphasized that this arrangement, that is, a piston flow system wherein a separate tank or cylinder **140** of gas propellant **142** is used to drive the suppressant **134** from a clean agent cylinder is exemplary only. The present invention is not particularly limited with regard to the manner by which fire suppressant **134** is delivered to the atomizing nozzles **112**.

For example, for some embodiments a superpressurized agent cylinder may be suitable. That is, the propellant and fire suppressant **134** may be disposed within a single cylinder or tank.

Other arrangements may be equally suitable.

As shown in Figure 1, the atomizing nozzles **112** are arranged in spaced relation throughout the area **114**. The atomizing nozzles **112** work by spraying the discharged fire suppressant **134** still in liquid form outward into a thin liquid fan **160**. Spraying the liquid out in a thin fan **160** produces a large surface area for the liquid, due to its thinning out as it is sprayed outward. The liquid rapidly vaporizes due to the large surface area, and the thin liquid fan **160** thins out to small droplets as it spreads outward.

Referring to Figures 3 and 4, each atomizing nozzle **112** has a nozzle body **162** and a deflector body **164**.

Referring to Figure 5, the nozzle body **162** includes a threaded inlet port **166** that mounts onto the threaded end **168** of the branch outlet pipes **130**. The threads of the inlet port **166** may be configured to correspond to the threaded inlet ports of the removed single round orifice jet nozzles (not shown) used on prior Halon 1301 systems so that the nozzles **112** can replace the Halon nozzles to provide for a retrofit system. The inlet port **166** extends along the nozzle axis **170** (also referred to as the vertical axis) until it intersects a flow surface **172** of the nozzle body **162**.

The flow surface **172** extends radially outward from the nozzle axis **170** to form a top annular edge **174** of a circumferential outlet slot **176**. The deflector body **164** includes a deflector surface **178** in spaced relation to the flow surface **172** of the nozzle body **162**. The deflector surface **178** extends radially outward from a center point **180** defined by the intersection of the axis **170** and the deflector surface **178** to a bottom annular edge **182** to define the circumferential outlet slot **176** in combination with the top annular edge **174**.

Thus, the nozzle body and deflector body surfaces **172, 178** define a flow passage **184** therebetween that extends radially outwardly to the circumferential outlet slot **176**. The flow passage **184** converges radially outwardly toward the circumferential outlet slot **176** that extends at least part of the way around the axis **170**. The nozzle body **162** and deflector body **164** may be secured together with screws **186** or any other fastener or other suitable securing device. In the embodiment illustrated, the screws **186** extend through counter-bore holes **188** in the nozzle body **162** and are fastened into axially projecting threaded bosses **190** that project into the holes **188**. The bosses **190** and holes **188** are arranged at spaced angular positions about the axis **170** but preferably radially inward of the outlet slot **176**.

The nozzles **112** atomize the fire suppressant by spraying the fire suppressant **134** out of the circumferential outlet slot **176** forming the thin liquid fan

160. Fire suppressant **134** enters the inlet port **166** axially is redirected radially outward through flow passage **184** where it is discharged and sprayed radially outward in the shape of a thin liquid fan **160** for vaporization.

In addition, with reference to Figure 5, vanes **192** are disposed within the flow passage **184**. (The vanes are not illustrated in Figure 4, for clarity.) The vanes are arranged so as to impart a tangential velocity component relative to the axis **170** to fire suppressant **134** passing through the flow passage **184**.

Figure 5 includes a vector diagram illustrating an exemplary arrangement of the sort described above.

Fire suppressant **134** passing through flow passage **184** exits with a velocity vector **194** of $\vec{U}$. This velocity vector **194** may be separated into two components, a radial velocity component **196** that is radial with respect to the axis **170**, and a tangential velocity component **198** that is tangential to the axis **170**. As illustrated, the radial component **196** is U_R, and the tangential component **196** is U_T.

In other words, as the fire suppressant **134** exits the flow passage **184**, and thus exits the nozzle **112**, it has not only linear motion radially outward from the axis **170**, but also angular or rotational motion about the axis **170**.

In turn, when the fire suppressant **134** begins to interact with the air (or other fluid) in the volume surrounding the nozzle **112**, it produces a rotational motion of both the fire suppressant **134** and the air. Thus, not only the fire suppressant **134** itself but at least a portion of the air in the protected volume undergoes a rotary or swirling motion. Typically this rotational motion is at least substantially centered on the axis **170**.

The distribution of fire suppressant **134** within the protected volume may be considered somewhat analogous to an arrangement wherein one liquid is added to another and then stirred. However, instead of simply being "poured" into the air, or otherwise added in a purely linear fashion, with a nozzle **112** in accordance with the principles of the present invention the fire suppressant **134** is added with a tangential velocity component **198** such that both the fire suppressant **134** and the surrounding air are "stirred".

Such an arrangement is illustrated in Figure 2. Therein, the air/suppressant mixture produced near the nozzles **112** is shown to have a rotational motion **200**. Although for purposes of simplicity only a few arrows indicative of the rotational motion **200** are shown, and they are illustrated relatively close to the nozzles **112**, the actual volume of air/suppressant that is made to move in a rotational manner may be substantial.

In addition, although in Figure 2 all of the nozzles **112** produce rotational motion **200** in the same direction, this is exemplary only. In a system

having multiple nozzles **112**, it is not necessary for all nozzles **112** to produce the same direction of rotational motion **200**.

Although the rotational motion is referred to in places herein as a "stirring" action, it is emphasized that the rotational motion does not have to be added by an external "stirring" source. Rather, it is the tangential velocity component **198** of the fire suppressant **134** itself that induces the rotational motion of fire suppressant **134** and air.

Such an arrangement may yield a number of advantages over conventional arrangements for purely radial distribution.

As may be understood for example with respect to the analogy of stirred liquids, a fluid fire suppressant **134** may mix more rapidly with the surrounding air or other ambient fluid in the protected area if the fire suppressant **134** and air are "stirred" together by imparting a tangential velocity to the fire suppressant **134**.

Similarly, imparting a tangential velocity component **198** to the fire suppressant **134** may yield a more uniform distribution of fire suppressant **134** within the protected volume. For example, even if a specific nozzle arrangement initially produces plumes of fire suppressant **134**, or an otherwise uneven initial distribution, the rotational motion of the fire suppressant **134** and air typically tends to facilitate uniform mixing of those fluids.

In addition, providing a tangential velocity component **198** to the fire suppressant **134** may result in more efficient use of fire suppressant **134**. For example, as noted above, distribution of fire suppressant **134** may be more rapid and/or more uniform with the rotary motion provided by a nozzle **112** in accordance with the principles of the present invention than with a purely radial dispersion of fire suppressant **134**.

Functionally, in order to begin to suppress a fire within a given time, it may be desirable to produce within that time a minimum concentration of fire suppressant **134** throughout the volume that is to be protected.

However, if the speed of distribution is low, portions of the volume to be protected may be "starved", that is, they may not receive sufficient fire suppressant **134** to reach the minimum concentration in the time allowed. It may be possible to compensate for this by discharging more fire suppressant **134** than is absolutely required to reach the minimum concentration that is desired throughout the protected volume. However, such an arrangement typically may be inefficient, since greater amounts of fire suppressant **134** are used to offset a low distribution speed. Also, additional nozzles, conduits, etc. may be necessary to facilitate the distribution of the additional fire suppressant **134**.

Essentially, then such an arrangement sacrifices efficiency for speed. However, as the speed of distribution increases, i.e. by imparting a tangential velocity component **198** to the fire suppressant **134**, the need to trade efficiency for speed of distribution may be reduced or eliminated.

Likewise, a similar trade-off may be made if the uniformity of fire suppressant **134** distribution is low. Additional fire suppressant **134** may be distributed, resulting in unnecessarily high levels of fire suppressant **134** in certain portions of the protected volume, in order to reach a minimum concentration of fire suppressant **134** in other portions of the protected volume. As with the speed trade-off described above, as the uniformity of distribution increases, i.e. by imparting a tangential velocity component **198** to the fire suppressant **134**, the need to trade efficiency for uniformity of distribution may be reduced or eliminated.

Furthermore, giving a tangential velocity component **198** to the fire suppressant **134** may result in more effective distribution of fire suppressant **134**. As noted, rotary motion of the air and fire suppressant **134** may improve the mixing of those fluids. As a result, portions of the protected volume which may be difficult to reach with a simple radial distribution of fire suppressant **134** - for example, regions behind equipment or other obstacles - may more readily be reached by fire suppressant **134** when a rotary motion as present, as with the present invention.

The specific dynamics of a given mixture of fire suppressant **134** and ambient fluid - i.e. the precise magnitudes of improvements in speed of distribution, etc. - will depend on a variety of factors, including but not limited to the specific properties of the individual fire suppressant **134** and ambient fluid; however, as may be seen from experience with liquids, rotational motion typically provides for increased speed of mixing, greater uniformity of mixing, etc.

The precise structure and arrangement of the vanes **192** may vary from embodiment to embodiment. In the arrangement illustrated in Figure 5, six straight vanes **192** are shown, distributed evenly about the full circumference of the nozzles **112**. However, this is exemplary only, in several regards.

First, the number of vanes **192** may vary. Likewise, the relative distribution of the vanes **192** may vary; for example, it is not necessary for the vanes to be evenly spaced.

In addition, the shape of the vanes may vary from embodiment to embodiment. Figure 6, for example, shows another exemplary arrangement, wherein the vanes **192** are curved. Other arrangements also may be equally suitable.

Typically, the vanes **192** within a given nozzle **112** will have at least approximately the same shape, and will be spaced at least approximately evenly around the axis **170**. This may be seen in Figures 5 and 6, wherein all of the vanes

192 are similarly straight and similarly curved, respectively, and wherein the vanes **192** are spaced evenly. The vanes **192** thus define therebetween a plurality of similar sections within the flow passage **184**.

However, an arrangement of identical vanes **192** that are spaced at identical intervals around the axis **170** is exemplary only. In particular, minor variations in the shape of the sections of the flow passage **184** defined by the vanes **192**, may be suitable. For example, Figures 5 and 6, the bosses **190** project slightly into each section of the flow passage **184**, and thus the sections are not identical. However, in the exemplary embodiments illustrated therein, the sections are similar in shape, and in particular the width of each section at its outer edge is essentially identical.

Although Figures 5 and 6 show arrangements wherein the flow passage **184** extends a full 360° around the axis **170**, this is exemplary only. It is not necessary for the vanes **192**, or the flow passage **184** to extend a full 360° around the axis **170** of the nozzles **112**, or for the vanes **192** to be distributed about the entire circumference of the nozzle **112**. For example, Figure 7 shows a cross section of an exemplary nozzle **112** wherein the vanes **192** and the flow passage **184** extend less than 360° around the axis **170**, specifically 180°.

As with the 360° arrangements shown in Figures 5 and 6, the exemplary arrangement in Figure 7 also has vanes **192** that are approximately the same shape, and are spaced approximately evenly around the axis **170**. Thus, although the flow passage **184** of a 180° nozzle **112** as in Figure 7 is different in overall shape from a that of a 360° nozzle **112** as shown in Figures 5 and 6, the several sections of the flow passage **184** in the 180° nozzle **112** of Figure 7 nevertheless may be similar to one another. In particular, as may be seen in Figure 7, the width of each section at its outer edge may be essentially identical.

A 360° nozzle **112** such as that shown in Figure 5 sprays a thin liquid fan **160** all or substantially all of the way around the nozzle, the 360° fan **160** then quickly dispersing into the gas fire suppressant **134**. By contrast, a 180° nozzle **112** as shown in Figure 7 sprays a thin liquid fan **160** about one half of the way around the nozzle. Such an arrangement may be advantageous, for example, for preventing liquid interference between the thin liquid fan **160** with the walls **122**, while nevertheless quickly dispersing the fire suppressant **134**.

Other arrangements, in addition to 360° and 180° nozzles **112**, may be equally suitable. In addition, for systems having more than one nozzle **112**, it may be suitable to combine nozzles having flow passages **184** of differing angular extent (thus producing distributions of fire suppressant **134** having differing angular extent) in the same system.

In addition, the nozzle **112** may spray in a trajectory that is angled vertically upward or downward from the axis **170**. For example, a downward angle of between about 45° and about 90° relative to the vertical nozzle axis **170** may be suitable, though other angles may be equally suitable.

For example, Figure 4 shows an embodiment wherein the flow passage **184** is defined so as to be conical in shape. As shown, it has a slight downward angle, in the range of 10° to 15° from horizontal, or about 75° to 80° with respect to the vertical nozzle axis **170**.

However, such an arrangement is exemplary only. Angles other than those between about 45° and about 90° relative to the vertical nozzle axis **170** may be suitable. In particular, an angle of 90° relative to the vertical nozzle axis **170**, that is, at 0° with respect to the horizontal, may be equally suitable. Such an arrangement is illustrated in Figure 8.

In an arrangement such as that illustrated in Figure 8, the fire suppressant **134** would be distributed in a thin liquid fan **160** that is, at least initially upon leaving the nozzle **112**, essentially horizontal.

Returning to the arrangement of the vanes **192**, the vanes **192** also may be oriented to produce a variety of vector ratios. For example, the ratio of the magnitude of the tangential velocity component U_T of the suppressant **134** to the magnitude of the radial velocity component U_R of the suppressant **134** may be at least 1:10.

However, the ratio of the magnitude of the tangential velocity component U_T of the suppressant **134** to the magnitude of the radial velocity component U_R of the suppressant **134** is not particularly limited, so long as the circular motion described herein is produced thereby. For example, the ratio of the magnitude of the tangential velocity component U_T of the suppressant **134** to the magnitude of the radial velocity component U_R of the suppressant **134** may be at least 1:5.

The ratio of the magnitude of the tangential velocity component U_T of the suppressant **134** to the magnitude of the radial velocity component U_R of the suppressant **134** may be at least 1:3.

The ratio of the magnitude of the tangential velocity component U_T of the suppressant **134** to the magnitude of the radial velocity component U_R of the suppressant **134** may be at least 1:2.

The ratio of the magnitude of the tangential velocity component U_T of the suppressant **134** to the magnitude of the radial velocity component U_R of the suppressant **134** may be at least 1:1.

The ratio of the magnitude of the tangential velocity component U_T of the suppressant **134** to the magnitude of the radial velocity component U_R of the suppressant **134** may be at least 2:1.

The ratio of the magnitude of the tangential velocity component U_T of the suppressant **134** to the magnitude of the radial velocity component U_R of the suppressant **134** may be at least 3:1.

By varying this ratio, properties such as the speed of rotational motion of fire suppressant **134** and air, the total volume of space wherein the air is made to rotate, etc. likewise may be varied.

For certain embodiments, the vanes **192** may be adjustable, such that the ratio of the magnitude of the tangential velocity component U_T of the suppressant **134** to the magnitude of the radial velocity component U_R of the suppressant **134** may be varied. In addition, for certain embodiments the vanes **192** may be adjustable remotely, and/or automatically. Alternatively, certain embodiments of the nozzle **112** may be adapted to receive any of several configurations of vanes **192**, so as to produce different such ratios.

For certain embodiments of the nozzle **112**, the vanes **192** may be removable, and/or replaceable.

The vanes **192** may be separate, individual components, or they may be part of an integral one-piece unit. For example, such an integral unit may facilitate replacement and/or retrofitting of vanes **192** in a given nozzle **112**.

The nozzles **112** themselves likewise may be retrofitted to an existing fire suppression system.

Vanes **192** and/or nozzles **112** may be provided in kit form, for retrofitting to existing nozzles and/or fires suppression systems respectively.

The above specification, examples and data provide a complete description of the manufacture and use of the composition of the invention. Since many embodiments of the invention can be made without departing from the spirit and scope of the invention, the invention resides in the claims hereinafter appended.

We claim:

1. An atomizing nozzle, comprising:

a nozzle body and a deflector body secured together in fixed relation, said nozzle body comprising an inlet port therethrough adapted for connection with an outlet port, so as to receive fluid therefrom;

a flow passage defined between said deflector body and said nozzle body, said flow passage extending radially outwardly from said inlet port to a circumferential outlet slot, said circumferential outlet slot being defined between said nozzle body and said deflector body and extending at least partially around said nozzle, said flow passage defining an axis thereof; and

a plurality of vanes disposed in said flow passage, said vanes being arranged so as to impart a tangential velocity component relative to said axis to fluid flowing through said flow passage;

wherein:

said nozzle is disposed such that suppressant passing therethrough enters an area; and

said vanes are arranged such that said tangential velocity component is sufficient to impart to gas in said area a rotational motion about said axis.

2. The atomizing nozzle of claim 1, wherein:

a ratio of a magnitude of said tangential velocity component of said suppressant to a magnitude of a radial velocity component of said suppressant is at least 1:10.

3. The atomizing nozzle of claim 1, wherein:

said flow passage extends 360° around said axis.

4. The atomizing nozzle of claim 1, wherein:

said flow passage extends less than 360° around said axis.

5. The atomizing nozzle of claim 4, wherein:

said flow passage extends 180° around said axis.

6. A fire suppression system, comprising:

a supply of a volatile liquefied-gas fire suppressant having a vapor pressure sufficient to form a gaseous mixture with air that does not support combustion for extinguishing fires;

a pipe network connected to said supply, said pipe network comprising at least one outlet port;

at least one atomizing nozzle according to claim 1 in communication with said outlet port

7. A kit for retrofitting an atomizing nozzle, said nozzle comprising:

a nozzle body and a deflector body secured together in fixed relation, said nozzle body comprising an inlet port therethrough adapted for connection with an outlet port, so as to receive fluid therefrom; and

a flow passage defined between said deflector body and said nozzle body, said flow passage extending radially outwardly from said inlet port to a circumferential outlet slot, said circumferential outlet slot being defined between said nozzle body and said deflector body and extending at least partially around said nozzle, said flow passage defining an axis thereof;

said kit comprising:

a plurality of vanes adapted to be disposed in said flow passage in an arrangement so as to impart a tangential velocity component relative to said axis to fluid flowing through said flow passage;

wherein

said nozzle is disposed such that suppressant passing therethrough enters an area;

said vanes are adapted to be arranged such that said tangential velocity component is sufficient to impart to gas in said area a rotational motion about said axis.

8 The kit of claim 7, wherein:

said vanes are adapted to be arranged such that a ratio of a magnitude of said tangential velocity component of said suppressant to a magnitude of a radial velocity component of said suppressant is at least 1:10.

9. The kit of claim 7, wherein:

said vanes comprise a single integral unit.

10. The kit of claim 7, further comprising:

instructions for retrofitting said nozzle.

11. A kit for retrofitting a fire suppression system, said system comprising:

a supply of a volatile liquefied-gas fire suppressant having a vapor pressure sufficient to form a gaseous mixture with air that does not support combustion for extinguishing fires; and

a pipe network connected to said supply, said pipe network comprising at least one outlet port;

said kit comprising:

at least one atomizing nozzle according to claim 1.

12. The kit of claim 11, further comprising:

instructions for retrofitting said system.

13. A method of suppressing a fire, comprising:

communicating a volatile liquefied-gas fire suppressant to at least one nozzle, said nozzle defining an axis;

atomizing said fire suppressant with said nozzle so as to vaporize said fire suppressant to a gaseous state; and

imparting to said fire suppressant a tangential velocity component relative to said axis;

wherein:

said nozzle is disposed such that suppressant passing therethrough enters an area; and

said tangential velocity component is sufficient to impart to gas in said area a rotational motion about said axis.

14. The method of claim 13, wherein:

a ratio of a magnitude of said tangential velocity component of said suppressant to a magnitude of a radial velocity component of said suppressant is at least 1:10.

15. The method of claim 13, wherein:

said suppressant exits said nozzle in an arc extending 360° around said axis.

16. The method of claim 13, wherein:

said suppressant exits said nozzle in an arc extending less than 360° around said axis.

17. The method of claim 16, wherein:
said suppressant exits said nozzle in an arc extending 180° around said axis.

18. A method of suppressing a fire in an area, comprising:
communicating a volatile liquefied-gas fire suppressant to at least one nozzle, said nozzle defining an axis;
atomizing said fire suppressant with said nozzle so as to vaporize said fire suppressant to a gaseous state; and
imparting to gas in said area a rotational motion about said axis.

19. A method of retrofitting an atomizing nozzle, said nozzle comprising:
a nozzle body and a deflector body secured together in fixed relation, said nozzle body comprising an inlet port therethrough adapted for connection with an outlet port, so as to receive fluid therefrom; and
a flow passage defined between said deflector body and said nozzle body, said flow passage extending radially outwardly from said inlet port to a circumferential outlet slot, said circumferential outlet slot being defined between said nozzle body and said deflector body and extending at least partially around said nozzle, said flow passage defining an axis thereof;
said method comprising:
disposing a plurality of vanes in said flow passage, said vanes being arranged so as to impart a tangential velocity component relative to said axis to fluid flowing through said flow passage;
wherein:
said nozzle is disposed such that suppressant passing therethrough enters an area; and
said tangential velocity component is sufficient to impart to gas in said area a rotational motion about said axis.

20. The method of claim 19, wherein:
a ratio of a magnitude of said tangential velocity component of said suppressant to a magnitude of a radial velocity component of said suppressant is at least 1:10.

21. A method for retrofitting a fire suppression system, said system comprising:
a supply of a volatile liquefied-gas fire suppressant having a vapor pressure sufficient to form a gaseous mixture with air that does not support combustion for extinguishing fires; and

a pipe network connected to said supply, said pipe network comprising at least one outlet port;

said method comprising:

connecting at least one atomizing nozzle to said at least one outlet port, said nozzle comprising:

a nozzle body and a deflector body secured together in fixed relation, said nozzle body comprising an inlet port therethrough adapted for connection with said outlet port, so as to receive fluid therefrom;

a flow passage defined between said deflector body and said nozzle body, said flow passage extending radially outwardly from said inlet port to a circumferential outlet slot, said circumferential outlet slot being defined between said nozzle body and said deflector body and extending at least partially around said nozzle, said flow passage defining an axis thereof; and

a plurality of vanes disposed in said flow passage, said vanes being arranged so as to impart a tangential velocity component relative to said axis to fluid flowing through said flow passage;

wherein:

said nozzle is disposed such that suppressant passing therethrough enters an area; and

said tangential velocity component is sufficient to impart to gas in said area a rotational motion about said axis.

22. The method of claim 21, wherein:

a ratio of a magnitude of said tangential velocity component of said suppressant to a magnitude of a radial velocity component of said suppressant is at least 1:10.

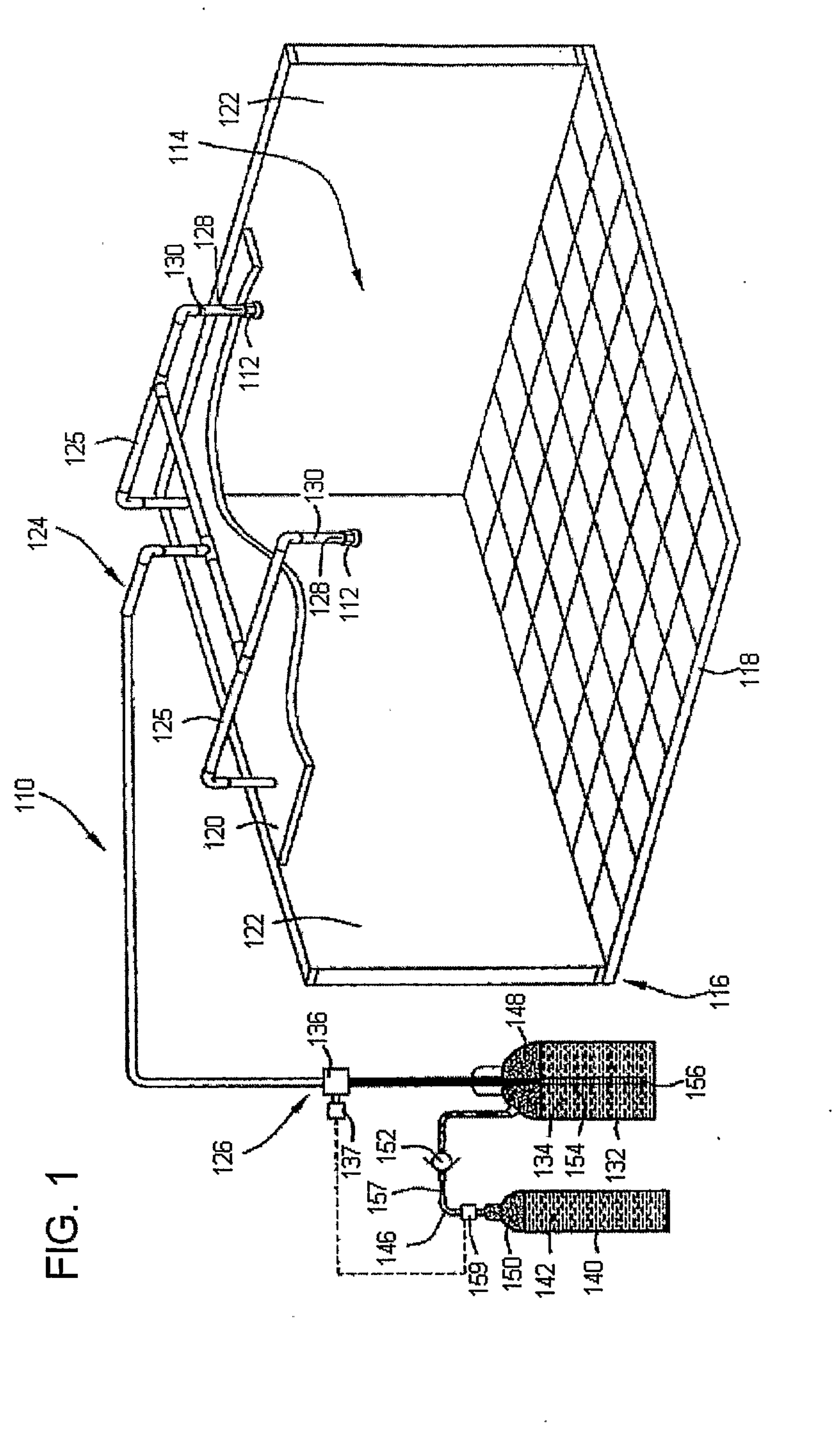
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FIG. 1

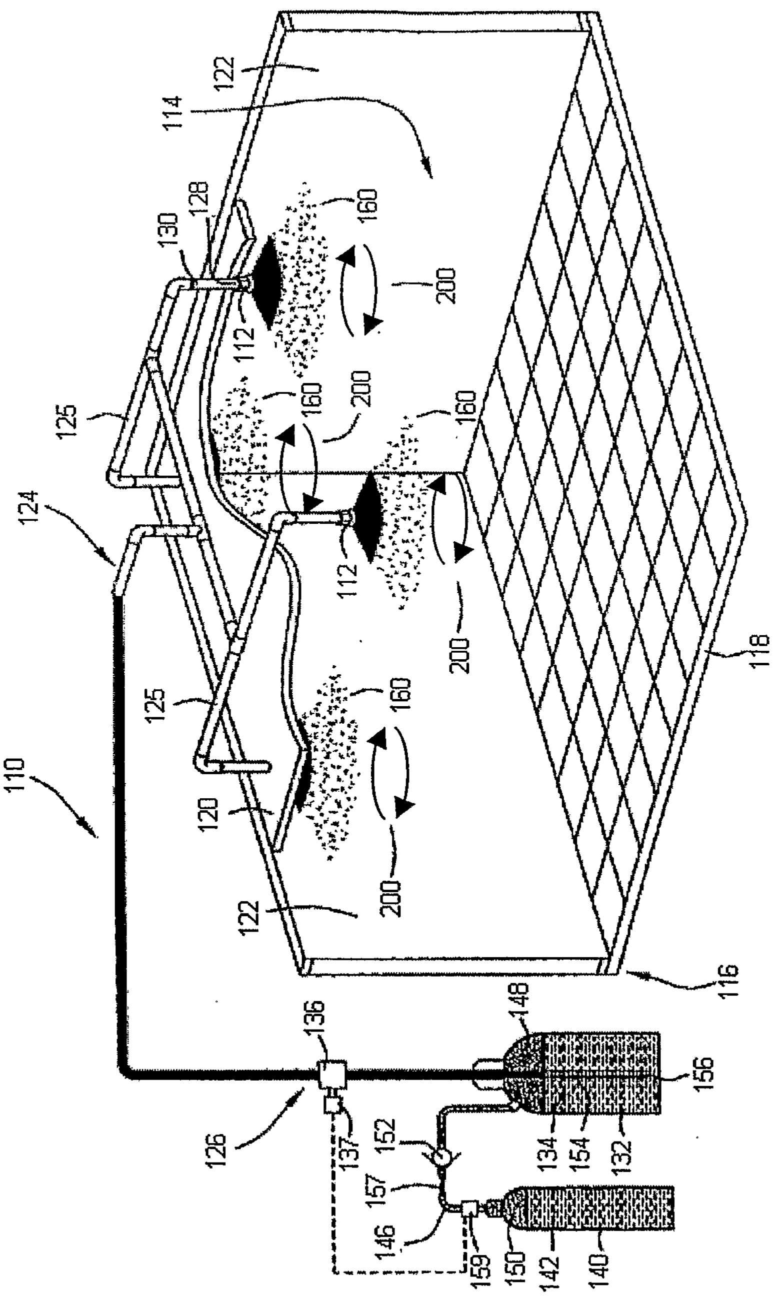
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FIG. 2

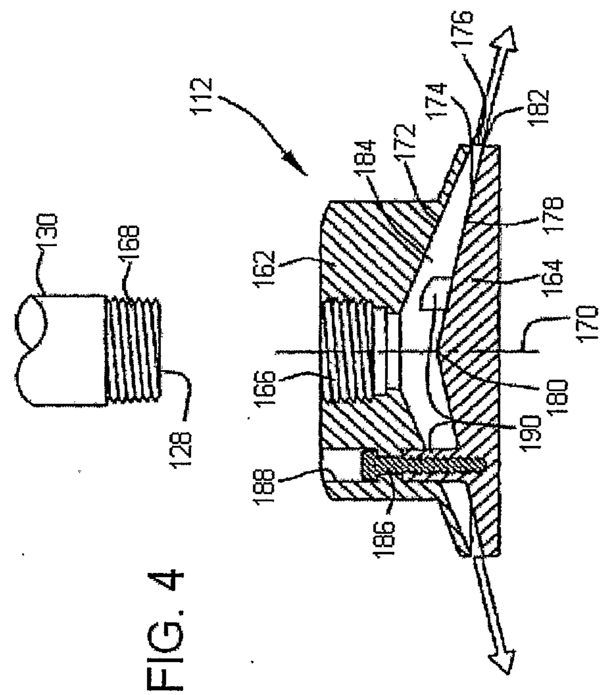
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FIG. 4

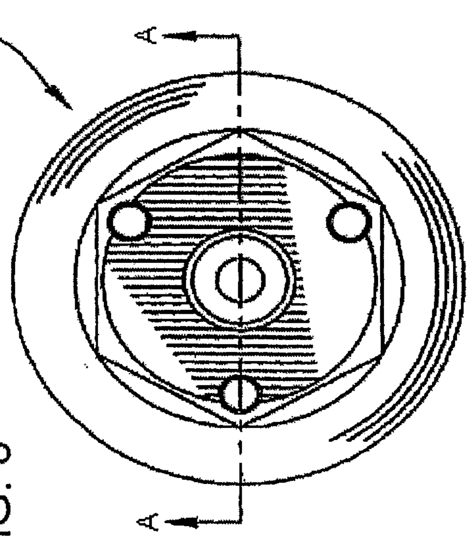
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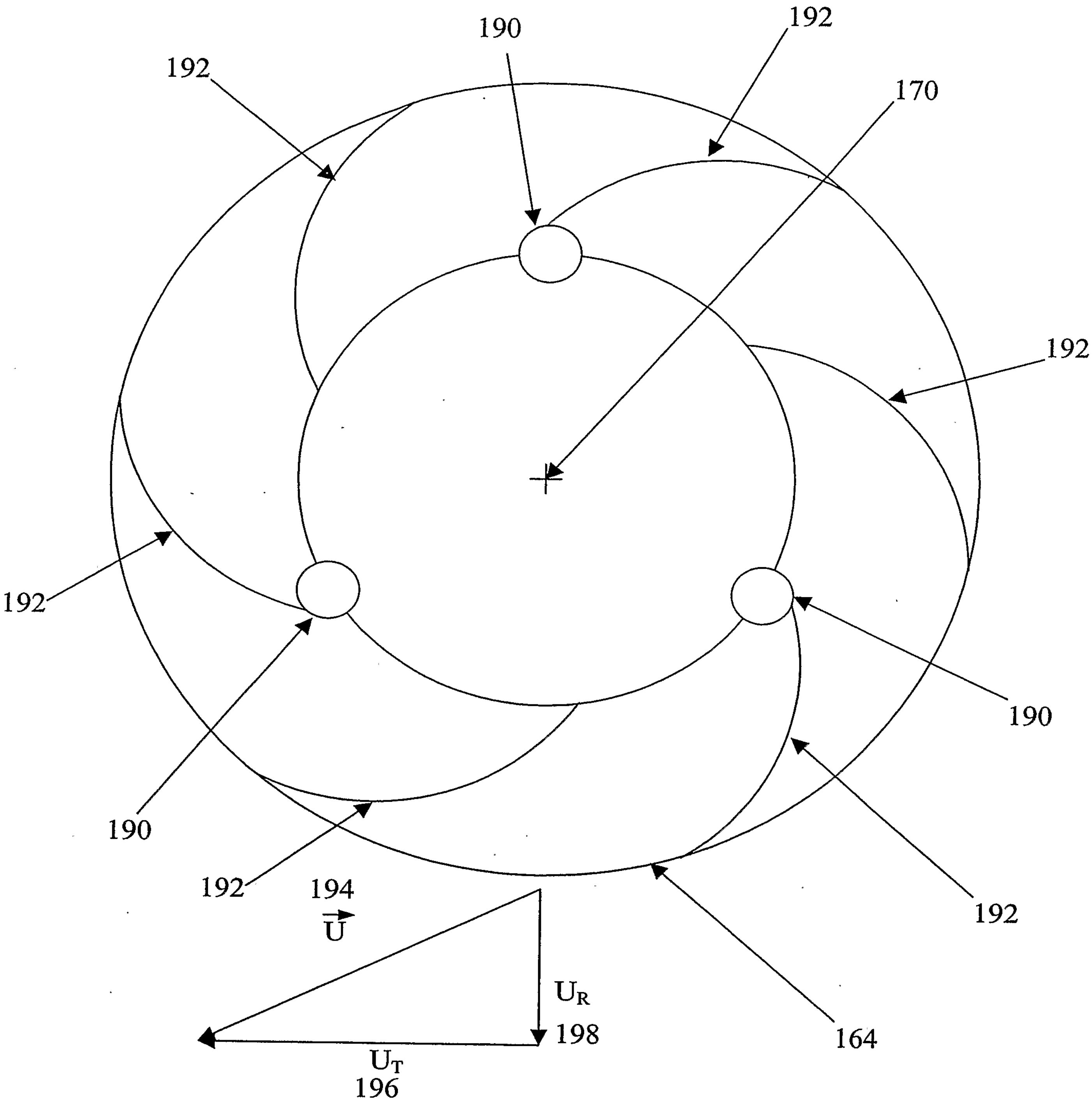
FIG. 3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U_R
198
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U_T
196

FIG. 5

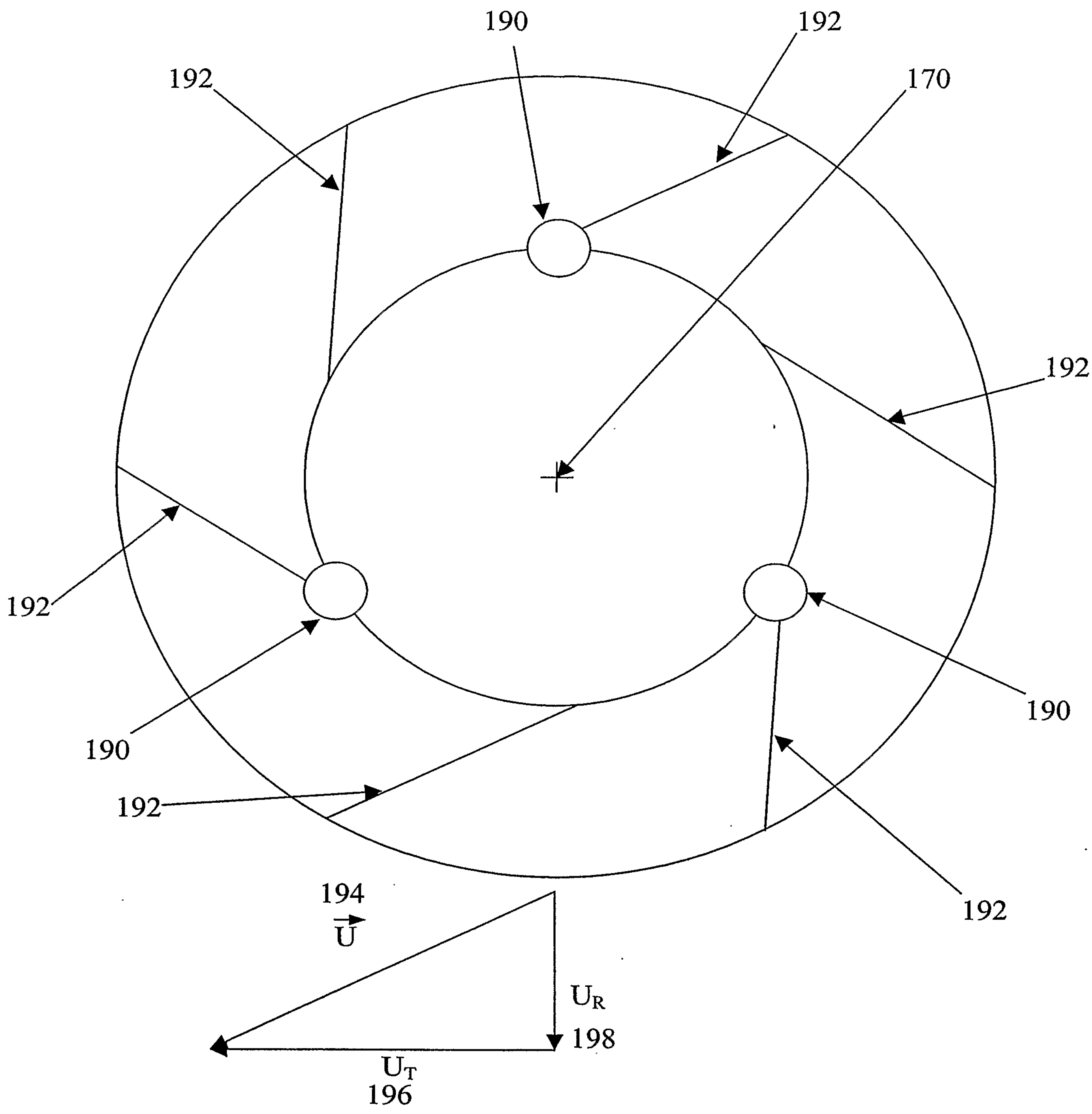

FIG. 6

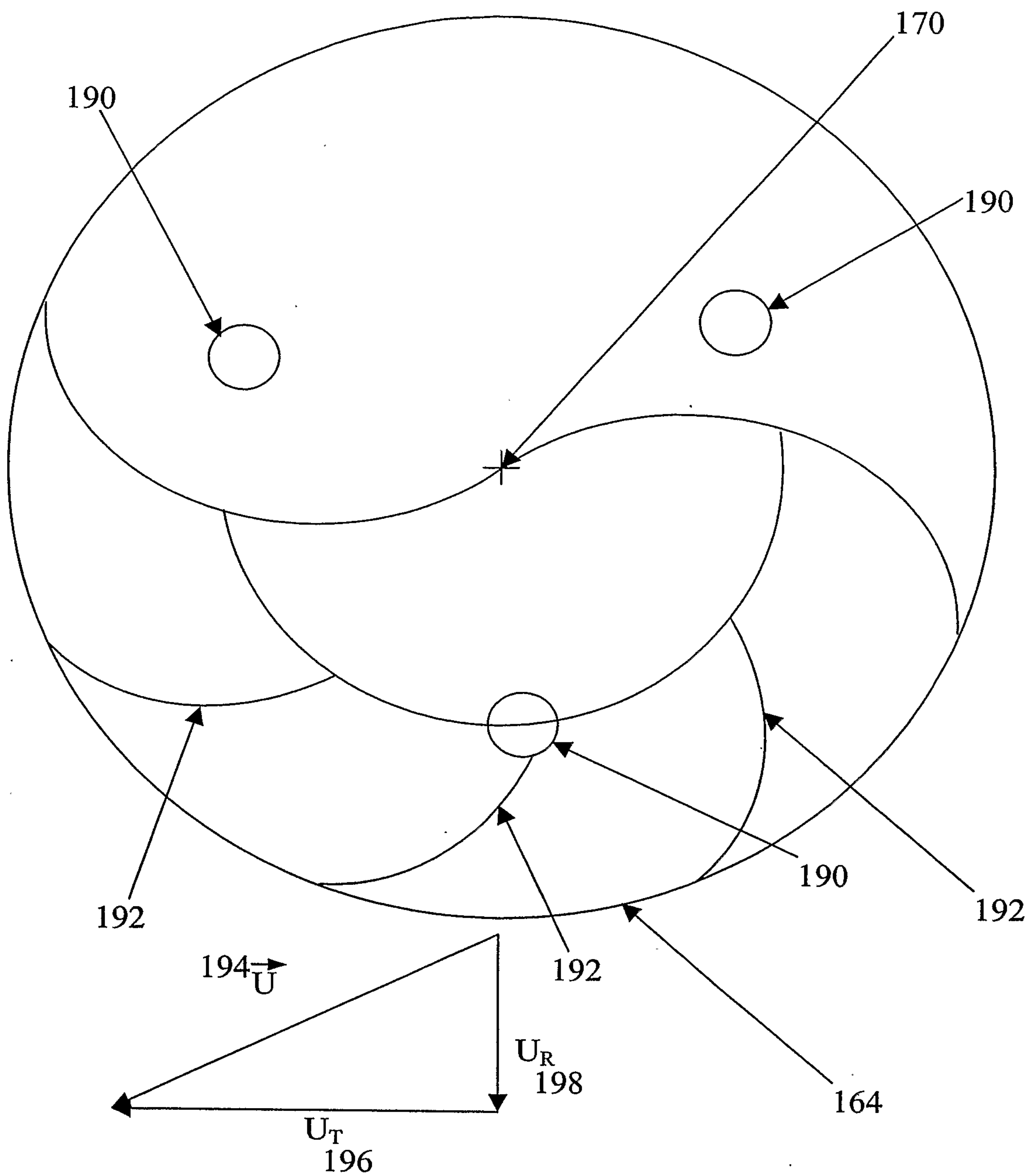

FIG. 7

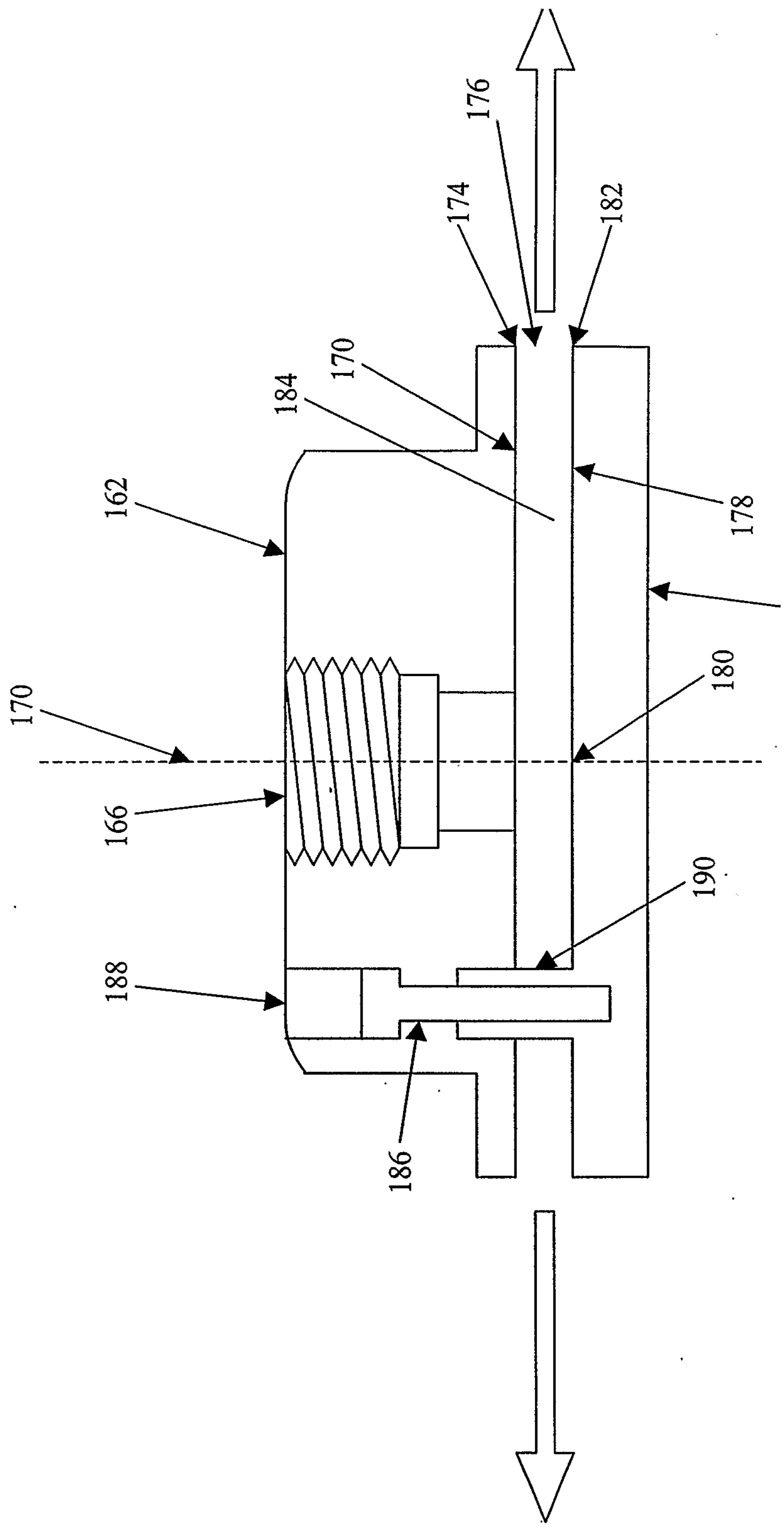

FIG. 8

INTERNATIONAL SEARCH REPORT

International Application No
PCT/US2005/019713

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 B05B1/26 A62C31/00 A62C31/02

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 B05B A62C

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X Y	US 1 933 428 A (HARRY JOSHUA BARTON) 31 October 1933 (1933-10-31) page 1, lines 40-100; figures	1-5,7-10 6,11,12
X Y	US 2002/027143 A1 (SCHOENROCK JOHN J ET AL) 7 March 2002 (2002-03-07) abstract; figures	21,22 6,11,12
X	FR 2 720 652 A (DISSE) 8 December 1995 (1995-12-08) the whole document	13-18
X A	GB 2 173 714 A (PHILIP STAFFORD * BAXENDALE; RAYMOND GEORGE * SHINN) 22 October 1986 (1986-10-22) abstract; figures 4-7	19,20 3-5, 15-17

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[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

° Special categories of cited documents :

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"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
14 September 2005	05/10/2005

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL – 2280 HV Rijswijk Tel. (+31–70) 340–2040, Tx. 31 651 epo nl, Fax: (+31–70) 340–3016	Endrizzi, S

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INTERNATIONAL SEARCH REPORT

International Application No
PCT/US2005/019713

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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A	GB 09985 A A.D. 1910 (SYDNEY HERBERT SMITH) 2 February 1911 (1911-02-02) figures -----	1

4

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International Application No
PCT/US2005/019713

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GB 191009985 A	02-02-1911	NONE	